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LETTER OF INTENT

PROTON ANGULAR DISTRIBUTION FROM ORIENTED ^{147}Tm HIGH SPIN ISOMER

N. J. Stone[1], J. Rikovska[1,2], M. Veskovic[3], J. Batchelder[4], V. Fedoseyev[5], U. Köster[6], V.I. Mishin[5] and the NICOLE and ISOLDE Collaborations.

[1] Oxford Physics, University of Oxford, Parks Road, OX1 3PU, UK.
[2] Department of Chemistry, University of Maryland, College Park, MD 20742, USA.
[3] University of Novi Sad, Novi Sad, Yugoslavia.
[4] UNIRIB/ORAU, P.O.Box 2008, Bldg 6008, MS 6374, Oak Ridge, TN 37831, USA
[5] Institute of Spectroscopy, Russian Academy of Sciences, 142092 Troitsk, Russia.
[6] PE Division, CERN, CH 1211 Geneva 23, Switzerland.

Spokesperson: N. J. Stone
Contact person: U. Köster

1 Introduction

Extensive investigation of direct proton radioactivity, pioneered in Daresbury in the 1980's and later carried on at Argonne and Oak Ridge Laboratories, has yielded a substantial body of data for both spherical and deformed proton emitters [1]. This data is essential in mapping the border of nuclear stability with respect to spontaneous one-proton decay. However, when, as hitherto, the emission is observed from a sample with random spatial orientation, the only observables open to experiment are the life-time of the particle decaying state and the energy spectrum of the emitting particles. Both these data are dependent only *indirectly* on the angular momentum make-up of the emitted wave.

The vital piece of information still missing is *direct* measurement of the angular momentum properties of the emission process through the angular distribution of the emitted particles with respect to the orientation axis of the proton emitting state. It is the aim of this letter to prepare adequate conditions for an experiment which will provide this essential information for the first time for the direct proton emitter ^{147}Tm.

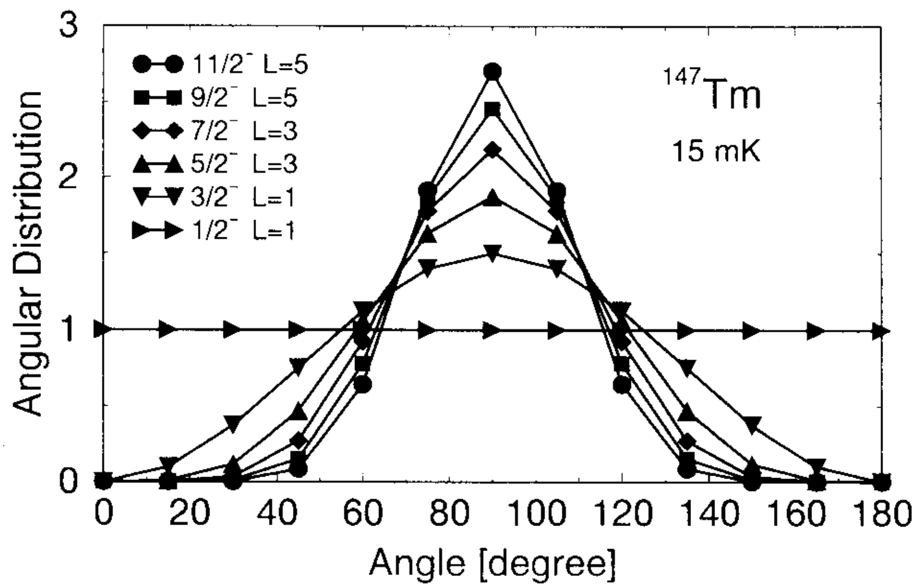
Most cases of direct proton emission cannot be studied by low temperature polarisation methods as they do not live long enough, after implantation to an iron foil, to be cooled to the necessary millikelvin temperatures. ^{147}Tm is one of the exceptional cases, as described below. ISOLDE is at present the only facility in the world where such an experiment can be performed, as it has the RILIS ion source, capable of production of the beam and the on-line low temperature nuclear orientation NICOLE facility.

2 Experiment

The half life of the high spin isomer of ^{147}Tm is 580(70) ms [2], comfortably long enough to allow orientation in the enormous [340T] hyperfine field existing at thulium nuclei implanted into iron (the estimated cool down time is less than 20 ms). The emitted proton energy is only just above 1 MeV, which, along with a difference of 5 units in angular momentum, predicted by model calculation, between emitter and daughter states, is thought to be the reason for the slow decay [2]. The proposed experiment will establish directly the angular momentum (L) of the emitted proton wave to the 0^+ ground state of ^{146}Er. From the L value, the spin of the high spin isomer in ^{147}Tm can be determined directly. It is assumed to the $11/2^-$ according to prediction of a spherical shell model. However, if the emitter state is not spherical, the spin value may be different. So the outcome of this experiment will detrmine uniquely both spin and shape of the emitter.

We stress that the results of this experiment do not depend on models of the barrier penetration process in cases when the proton decay goes to a ground state of an even-even nucleus and since then only one value of L is allowed by angular momentum selection rules. It follows that the probability of the proton decay, dependent on model of the emitter barrier penetration which needs to be included into any interpretation of the the measured

Figure 1: Calculated angular distribution of protons from ^{147}Tm as a function of proton wave angular momentum L and spin of the parent state.



half life, forms just a multiplication factor in the experimental angular distribution. In this way, the L-value of the proton wave and the emitter spin, extracted from angular distribution, are model independent.

The angular distribution of protons with energy E_p from a state with spin J_i feeding a daughter state J_f with channel spin $I_c = J_f \pm 1/2$ ($I_c=1/2$ for $J_f=0$) is expressed as:

$$W(E_p, T, \theta) = \sum_{\lambda=0}^{\lambda_{max}} B_\lambda(T) Q_\lambda R_\lambda(L, I_c) P_\lambda(\cos\theta)$$

where B_λ, Q_λ and P_λ are the orientation parameters, geometrical coefficinets and Legendre polynomials, respectively [3]. The R_λ coefficients, depending upon the spins of the states involved, upon partial wave L and upon the spin of the emitting particle, are defined in Ref. [4]. We illustrate the predicted angular distribution of protons from ^{147}Tm, oriented at 15 mK, as a function of J and L, in Fig. 1. It is clearly seen that the sensitivity of angular distribution to the combination of L and J_i is sufficient to distinguish different cases.

3 Technical feasibility

We request, as a feasibility test for the proposed experiment, measurement of the yield and isobaric contamination of ^{147}Tm from the RILIS ion source.

References

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